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THE DISTRIBUTION OF SKATES AND RAYS ALONG THE KENYAN COAST

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ABSTRACT

The distribution, abundance, reproductive biology and the economic importance of skates and rays along the Kenyan Coast was studied between January 1980 and December 1981. The common species described in this paper are *Raja miraletus, Taeniura lymna, Myliobatis aquila, Dasyatis thetidis, D. uarnak* and *D. sephen.* These fish were present throughout the year with increased catches being realised in August, December and March. The size distribution of each fish is described. Linear regression analysis of the length/weight relationship for all the species indicate allometric growth. *Raja miraletus, D. thetidis and D. uarnak* exhibit sexual dimorphism. All fish, except *Manta birostris*, are carnivorous, feeding on crustaceans, molluscs and fishes. The distribution of skates and rays is discussed with reference to depth, temperature, salinity and the monsoonal phenomena. Temperature changes and low salinity water during the rainy season may act as a trigger mechanism for spawning.

INTRODUCTION

Total landings of elasmobranchs was 46.7 tonnes, about 1% of the total marine fish landings of 4,336 tonnes in 1979 (Kenya Fisheries Department Annual Report 1979). These fishes are caught at numerous points along our coastline (Fig. 1) by fishermen using small and big sized canoes, sail and engine dhows and trawlers. Fishing gear consists of handlines, gillnets, trammel nets and trawlnets. The fish have been exploited for the Vitamin A content of their livers. They yield excellent leather, polishing agents, marketable flesh for human consumption and their fins are used in combs and Chinese cookery. Skates and rays have an evil reputation among fishermen because of their poisonous serrated tail spines and electric shocks that may be received by touching (Ochumba 1984). The meat of the pectoral fins or wings of these fishes is considered a delicacy among the Kenyan coastal people. Demand for such species depends upon a combination of factors, of which the most important are size and ease of skinning or winging the pectoral fins before they are marketed (Grzimek 1973, Holden 1978). Although skates and rays are regularly taken in bottom trawls, they form a small proportion (less than 10%) of the total catch by commercial trawlers. Their landed weight has shown an increment recently (Fig. 2).

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Skates and Rays belong to the Suborder Batoidei and are flattened dorso-ventrally, with pectoral fins united to the sides of the head. Incomplete fusion of the pectoral fins and abnormality has been observed by Chhapgar (1964). Skates are oviparous (Clark 1922) and the eggs are enclosed in a rectangular horny capsule. Holden (1975) observed that skates are serial spawners. The number of eggs laid by a mature female is over 140 per year. Rays are ovoviviparous, that is, eggs are produced which are hatched internally. Daiber and Booth (1960) found that the left ovaries of some rays were larger than those on the right. Males are considered to be mature when the claspers are fully grown, with the clasper cartilages rigid from calcification. Signs of maturity in females are distinct ova in the ovary, and expansion of the uteri to form loose sacs rather than thin, tight-walled tubes. Copulatory activity can be inferred from the evidence of clasper wounds in the cloaca of females. Sexual dimorphism has been observed by Darracott (1977) in some rays along the East African coast. Skates and dasyatid rays are carnivorous, while the manta ray is adapted to filter feeding on small fishes and planktonic crustaceans taken into the mouth and strained out of the water by means of a specialized branchial apparatus.

The common species during the period of study were: *Raja miraletus* (Blue Eye skate), *Taeniura lymna* (Ribbontail Ray), *Myliobatis aquila* (Duckbill Ray), *Dasyatis thetidis* (Thorntail Ray) and *Dasyatis uarnak* (Feathertail Ray). The major problem in assessing fisheries for skates and rays is that they are often grouped as a mixture of species or just labelled elasmobranchs which are not differentiated in the fishery statistics reports. The objectives of the study were three-fold. First, to identify the skates and rays found along the Kenyan coast. Secondly, to study their reproduction, distribution and abundance, and length/weight relationships. Thirdly, to estimate the biomass and to determine their economic importance.

PHYSICAL ENVIRONMENT OF THE STUDY AREA

The Kenyan coastline (Fig. 1) extends from 1° 30' S to 4° 30' S and is characterized by the presence of fringing coral reefs distributed at depths between 16 - 40 metres. The coastline is very irregular, indented and fronted by several islands of which the larger are in the northern part: Lamu, Manda, Pate and Kiwayu. Mombasa and Funzi Islands are found on the southern coast. The coastline including islands is 880 km long (Coppola 1982) and is broken by the rivers discharging into the Indian Ocean at Vanga, Mombasa, Mtwapa, Mida creek, the Sabaki Rivermouth, the Tana River and the extensive islands of the Lamu Archipelago. The continental shelf in many places along the coast is less than 4 km wide. The Kenyan waters can be divided into 4 parts. The North Kenyan Bank has a rocky bottom with soft corals and sponges. Off Ungama Bay the bottom is mostly sandy and muddy, and the area supports a good fishery (Nzioka 1982). The Malindi Bank area has hard corals and the area between Malindi Bank and Funzi is rocky and muddy.

The dominant feature of the surface currents in the Western Indian Ocean is the seasonal reversal of winds due to the monsoonal atmospheric circulation. The seasonal variation of the monsoonal wind currents (Duing 1970) are the South West Monsoonal (April - October) when the wind velocities exceed 20 ms $^{-1}$ and the current speeds 200 cm s^{-1} and the North West Monsoon (November - February) when circulation is generally weaker than the SW monsoon. The intermonsoon period is generally characterized by dry weather. The main current off the Kenya coast is the East African Coastal Current (EACC), which flows northward and parallel to the coast and is generally poor in nutrients (Birkett 1979). This current, which originates as a branch of the South Equatorial Current (SEC), is 200 km wide and 100 m in depth. During the Southern Monsoon, winds flow northward reinforce the EACC which then flows as a swift current crossing the equator to merge with the Somali Current. During the Northeast monsoon, the wind system blows southward against the EACC.

The water-mass distributions beneath the East African Coastal Current (Williams 1963, Warren et al. 1966, Quadfasel and Schott 1982) are summarised in Fig. 3 for depths where offshore trawls were made. The characteristics of these water masses may determine the depth distribution of rays and skates. Thermocline migration during the onset of the SW monsoon occurs at depths between 40-150m. Water temperatures along the Kenyan coast reach a surface maximum between 29.5 - 30.5° C (range 4.5 - 30.5° C); salinity 34.2 - 35.5‰ and dissolved oxygen 0.01 - 4.0 $mL.L^{-1}$. The North Kenyan Banks form a topographic barrier that deflects the East African Coastal Current seaward causing localised upwellings. The nutrient rich waters in the upwelling areas have pronounced effects on the food chain dynamics in this area. Records of pH, inorganic and total phosphate, nitrate and silica (Smith and Codispoti 1980) indicate waters dependent on the length and intensity of the monsoon. The long rains occur along the Kenyan Coast between March - May and short rains in October, so that flow from the rivers reaches a maximum from April to June. The brackish outflow from these rivers is kept close inshore by the prevailing northward flow of the East African Coastal Current.

MATERIALS AND METHODS

Specimens of skates and rays were taken from commercial trawlers, line fishing, and landings from the small-scale fishermen along the coast. The fishermen used shark nets set overnight, mostly of 6 and 8 inch stretched mesh size made of heavy ply twisted multifilament nylon. All fishing areas of the small scale fishermen were in water depths of 12 to 24 m and sheltered by a number of coral islands. In a few cases *Taeniura lymna* were taken by skin divers in shallow coralline areas. Study material from the open sea was collected by R. V. 'Ujuzi' during the FAO Project KEN/74/023 between January 1980 to June 1981 covering different fishing grounds and monsoons. Fishing gear consisted of a high opening bottom trawl with cod end mesh size 32 mm and a baloon trawl with cod end mesh size 40 mm. Each fishing operation lasted one hour and the catch rates were determined by weighing the total number of fish caught. The techniques of identifying and measuring skates and rays used in the study were those of Bigelow and Schroeder (1953), Hubbs and Ishiyama (1964), Ishiyama (1955) and Miller and Lea (1972). Identification keys used were Wallace (1967), Hulley (1969, 1972) and Smith (1977). The total length, disc length and width in centimetres of each specimen were taken along a straight line as illustrated in Fig. 4. A measuring board with a metallic ruler was used in measuring skates, while a tape measure was used for rays. Each fish was weighed in freshwet condition in kilograms. To determine the food eaten by skates and rays, the stomach contents of freshly caught specimens were examined and the food items identified as far as possible. The volume and frequency of the various food items for each fish studied were not determined. The presence of milt in males, embryos and clasper wounds in females was recorded.

The length/weight relationships for each species of fish was calculated using the relationship:

$$W = aL^{b} \text{ (Ricker 1975)}$$

where W = Weight, L = Length (either total length, disc length or disc width), a = a constant, b = the exponent. A logarithmic transformation of the above relationship was used as below:

$$\ln W = \ln a + b \ln L$$

Where the study material consisted of less than ten individuals the range of the measurements taken is given. Bottom substrate and the depth profiles of temperature and salinity were used to determine the fishes' distribution. The total catch of all skates and ray species were grouped together as 'Rays' and their proportion in a trawl catch compared to those of the dominant species. The functional regression value b less than 3 (Ricker 1975) was used to determine allometric growth.
Biomass estimates were calculated according to the formula:

$$B = MD \times A \text{ (Birkett 1979 and Gulland 1979)}$$

Where: B = biomass in metric tonnes (mt).
MD = mean density in metric tonnes per square nautical mile ($mt\ nmi^{-2}$)
A = area swept by the trawl net per unit time (nmi^2h^{-1}).

The mean density of rays was calculated from the mean catch rates on the basis that effective sweep of the trawlnet was 16.4 m and the average speed of towing was four knots. Under these conditions, the trawl would have swept an area of 0.035 nmi^2 per hour, so the density of fish is given by the formula:

$$\text{density of fish} = \frac{1}{0.035} \times kgh^{-1} \times 10^{-3} = 0.028\ kgh^{-1} \text{ (Birkett 1979)}$$

The fishing areas shown in Fig. 1 within certain depth contours were calculated by planimetering. Maximum sustainable yield (Y) was calculated from the surplus production model (Gulland 1979):

$$Y = 0.5\ (C + MB)$$

Where C = present catch, M = natural mortality and B = the biomass at the time of survey.

RESULTS

RHINOBATIDAE *(Shovel Nosed Skates)*

Two genera have been reported to occur in our waters, *Rhynchobatus djeddensis* and *Rhinobatus holcorhynchus* (Barnard 1925, Darracott 1977). During this study one female *R. djeddensis* was caught by a fisherman's gillnet at Vanga. It weighed 3.5kg.

RAJIDAE *(Skates)*

Raja miraletus (Fig. 5a) was the only species collected during the period of study. Skates are characterized by their dorsoventrally flattened rhomboidal disc, moderately slender tail, two dorsal fins, a membranous caudal fin, and lack of serrate tail spines. A large bluish-black ocellus surrounded by narrow rings of black and yellow at the base of each pectoral distinguishes *R. miraletus* from other skates. The dorsal surface of the disc is brownish with numerous small dark spots. The fish formed a significant proportion of the total catch in kg (16%) at depths between 250-800m, and it is not exploited as a source of food. A total of 117 fish were caught in October 1980, and in January and February 1981, of which 48 were male and 69 female. One egg case of *R. miraletus* (Fig. 5b) was collected by a beam trawl in March at a depth of 330 m off Kilifi. It weighed 12g and had a total length of 6.7 cm without horns.

Length and weight histograms for *R. miraletus* are shown in Fig. 6a. There was no difference in modal total length, disc length and disc width between male and female fish. The modal total length of all fish was 22.5 cm, disc length 21.3 cm, disc width 26.3 cm and weight 250 g. Female modal weight was 150 g. These results are comparable to those obtained by Hulley (1970) in his skate study on the west and south coasts of southern Africa. The male mean total length was larger than the female, while mean female disc length, disc width and weight were larger than those for males (Table la). Linear regression analysis of the length/weight relationship indicates that the growth in this fish is allometric and there is a significant difference between male and female fish (Table 2a). This supports the finding of Holden (1978) that there is a difference between the growth rates of male and female elasmobranchs. Six *Raja alba*, two *R. springeri* and one *R. stenorynchus* were recorded during the period of study.

TORPEDINIDAE *(Electric Rays)*

Three species representing two genera are known to occur off the Kenyan coast. One female *Torpedo marmorata* ('Taa maji' in Kiswahili, Fig. 5c) was trawled in October. It's total length was 31 cm, disc length 21 cm, disc width 26 cm and weight 345 g. Benbow (1976) reports that the largest fish may grow up to 1.3 metres in length. One female *Torpedo fuscomaculata* (Fig. 5d) was trawled in December off Malindi. It's total length was 47.5 cm, disc length 19.2 cm, disc width 20.6 cm and weight 730 g. Three female *Heteronarce garmani* (Fig. 5e) were trawled in December off Malindi with a disc width range between 90-120 mm.

GYMNURIDAE *(Butterfly Rays)*

One specimen of *Gymnura natalensis* (Fig. 5f) was caught in a gillnet and landed at Mombasa in November. It's total length was 41.4 cm, disc length 38.5 cm, disc width 79.9 cm and weight 4.0 kg. This fish is scarce and considered a delicacy by the local fishermen.

DASYATIDAE *(Stingrays)*

Taeniura lymna (Fig. 5g) is a common stingray found in East Africa (Benbow 1976) and is recognized by its colour, light grey covered with blue spots and the blue band on either side of the tail. The background of the dorsal surface is brownish-yellow and spots are absent on the tail. All specimens were caught in the shallow coral reef areas using gillnets and sometimes harpoons, handguns and spears at low tide. *Taeniura lymna* is exploited as a source of food and was available throughout the year, with more fish in November. A total of 51 fish were caught, of which 28 were identified as female and 23 as male. *Taeniura lymna* is ovoviviparous and two pregnant females were recorded in March. One female had 13 yellowish eggs on the left ovary and none on the right. The other female had a fully developed embryo with a total length including tail of 20.2 cm, a disc length of 8.25 cm, disc width of 9.5 cm and a weight of 100 g. The disc width of the pregnant females were 38 cm and 39 cm and they weighed 3.0 kg and 3.3 kg, respectively.

Length and weight histograms for *T. lymna* are shown in Fig. 6c. The modal total length was 27.5cm, and disc width and length were 26.3 and 24.4 cm., respectively. Thus, the disc is as wide as long. The mean total length of males was greater than that for females, while the mean disc length, disc width and weight of females were greater than those for males (Table 1b). Linear regression analysis of the length and weight relationship (Table 2c) indicates that growth is allometric and there was no significant difference between male and female fish.

Dasyatis thetidis (Fig. 5h) can be distinguished from other stingrays by its markedly thorny tail, a blunt snout and tubercles along the anterior margin of the disc. The tail is armed with 1-2 serrated spines. On each side of the spine are a pair of grooves supplied with a powerful irritant toxin from connected poison glands. The colour of the dorsal surface varies from a uniform dark brown to greyish black and the ventral surface is whitish. Smith (1957) described this fish as *D. lubricus* which Wallace (1967) confirmed was a synonym of *D. thetidis*. The depth distribution of the fish was between 5-400 m. The fish was landed by the local fishermen and formed 25% by weight of the commercially important trawl catches. The trawl catches in August were higher than for any other month during the period of study. Further work is needed to evaluate the possible increase in biomass of this fish in August.

One hundred and eighty-four fish were caught of which 63 were male and 98 females. The mean disc width and length were, respectively, 74 cm and 68.8 cm. This supports Barnard (1925) and Wallace (1967) who reported that disc width is greater than the disc length (see Table 1c). Length and weight frequency histograms are shown in Fig. 5d. The modal total length, disc length, disc width and weight were not significantly different for males and females. The mean were larger than those for males (Table lc). Linear regression analysis of the disc length, disc with and weight relationship (Table 2d) indicates that growth in this fish is allometric and that disc length and weight gives a better relationship in females than males. An examination of the stomach contents of *D..thetidis* indicated that its food consisted of oysters, crabs, shrimps, eels and fishes, *Sardinella spp., Leiognathus sp., Nemipterus sp., Stolophorus sp., Upeneus spp., Platycephalus sp., Synagrops sp.,* and a flatfish.

Pregnant female *D. thetidis* were recorded in November (1 specimen), December (2 specimens) and January (1 specimen). Females collected in this survey carried between 7-18 eggs in their ovaries. The ovarian eggs were small and filled with yolk. The eggs were between 2.2 to 5.8 cm in diameter and were encased in a yellowish-white membrane. Males with disc width greater than 50 cm were found to have rigid claspers. They possessed enlarged left testes, and when these were cut a milky fluid was released, indicating that the males were mature. Evidence of clasper wounds on the cloaca of one female was observed in December. This one observation is not enough to confirm that spawning activity starts around December.

Dasyatis uarnak (Fig.5i) can be identified by its variegated dorsal surface. The background colour of the dorsum is brown to black, upon which is superimposed a variable matrix of dark yellowish lines. The ventral surface is white. *D. uarnak* is widespread in the tropical Indo-pacific and is very common on the coasts of Natal, East Africa and the East Indies (Barnard 1925, Smith 1961 and Wallace 1967) A total of 37 fish were caught of which 19 were male and 18 female. The specimens were caught by lines set for 8 hours at a depth of 100m. Length, and weight histograms are shown in Fig.6e. The modal total length, disc length, disc width and weight were 70 cm, 65 cm, 75 cm and 16.3 kg, respectively. The mean total length, disc length, disc width for males were greater than that for females. Female mean weight was greater than the male mean weight (Table 1d). Mean disc width was 76.6 cm and disc length 69.2 cm. This suggests that the disc is wider than long for mature *D. uarnak*. Two juveniles were caught in March at the Mombasa estuary. The minimum total length including the tail was 94 cm, disc length 22 cm, disc width 15 cm and weight 1.0 kg. Linear regression analysis of the length and weight relationship indicates allometric growth (Table 2e).

Dasyatis sephen (Fig 5j) is a widespread dasyatid ray in the Indian Ocean, Red Sea and the Western Tropical Pacific Ocean. It has been recorded from the east coast of Africa, and from Seychelles and Phillipines (Smith 1961, Wallace 1967). This species is readily recognized by its extremely broad lower cutaneous fold which is 2-3 times as deep as the tail and extends more than half way to its tip. The dorsal surface is yellowish brown, becoming darker towards the tail. The caudal fold and the filamentous part of the tail is black. A total of 27 fish were trawled at depths between 50 - 280m, of which 19 were males and 9 females. Length and weight frequency histograms are shown in Fig.6f. The modal disc length of all fish was 65 cm, modal disc width 75 cm and the modal weight 15 kg. Linear regression analysis of the length and weight relationship indicates that growth in this fish is allometric (Table 2f). The results of stomach content analysis of one specimen showed that the food consisted of squid, shrimp, lobster, crabs and the fishes *Saurida sp., Thyrssites spp.,* and *Synagrops sp.* The muscle tissues of this fish appeared oily, and it is not exploited as a source of human food.

MYLIOBATIDAE *(Eagle Rays)*

Myliobatis aquila (Fig. 5k) is widespread in the Indian and Atlantic Oceans and in the Mediterranean Sea (Barnard 1925, Wallace 1967). The species is characterized by a prominent head, short and rounded snout, and a wider conically pointed disc with slightly concave hind margins. A dorsal fin is situated posteriorly to the pelvic fins and just before the tail. Males have a small conical horn above each orbit. This fish was landed by the local fishermen at Msambweni, Vanga and Malindi. It was caught by trawling in January in depths ranging between 25 - 280 m and formed 5% by weight of the commercially important trawl catches. Fifteen specimens were available for examination, of which 9 were female and 6 male. The length and weight histograms are shown in Fig. 6b. The modal total length was 65 cm, modal disc length 55 cm, modal disc width 95 cm and modal weight 12.5 kg. Linear regression analysis of length/weight relationship indicates that growth in this fish is allometric.

Pteromylaeus bovinus (Duckbilled stingray, Fig. 5l) is easily distinguished from *M. aquila* by its long fleshy snout and by the location of the dorsal fin between the pelvics. Nine fish were caught during the period of study, 6 were trawled off the Malindi area and 3 were landed by fishermen at the Mombosa Old Port. Total length range was 85-189 cm, disc length 65-126 cm, disc width 71-190 cm and weight 4.0-20.5 kg. The results of stomach content analysis of two fishes showed that the food of *P. bovinus* consisted of big and small prawns, the fishes *Leoignathus sp., Upeneus sp., Stolephorus sp., Nemipterus sp., Platycephalus sp.*, and *Synagrops sp.*

Aetobatis narinari (Fig. 5m) is a cosmopolitan species that occurs along tropical and subtropical shores in the Atlantic, Indian and Pacific oceans (Barnard 1925, Bigelow and Schroeder 1953, Wallace 1967). The colour pattern on the dorsal surface consists of white spots superimposed upon a blue/black background and the venter is whitish. Five fish were caught during the study, 3 from shark nets set for 14 hours at Vanga and 2 trawled off Malindi. Disc length range was 60-95cm, disc width 82-145cm and weight 7.0 - 60 kg.

MOBULIDAE (Devil Rays)

One female *Manta birostris* (Manta ray, Fig. 5N) was entangled in the Kenya Fisheries Department's fishing nets at Waa, Kenya South Coast, in November 1980. Its length excluding tail was 220 cm, disc length 200 cm, disc width 460 cm, mouth width 80 cm and weight 70 kg. Fishermen encountered this fish in shallow areas in March.

FISHERY

The monthly variation in trawl catches (Table 3) and catch rates (Fig. 7) indicates that rays were present throughout the year, with increased catches in August, December and March. *Dasyatis thetidis* dominated the catch in November and December, while *D. uarnak* and *D. sephen* were dominant in July and November. Several eagle-rays (*Myliobatis aquila* and *Aetobatis narinari*) of 30-50 kg. each were also caught throughout the year. Smaller rays were represented by the guitarfishes (*Rhynchobatis djeddensis*). The various dasyatid ray species catches ranged from 30 to 500 kg/hr off Ungama Bay, the North Kenya Banks and Malindi in January, July and November.

More rays were landed at Vanga, South coast, than any of the fish landing stations. Using the present catch (C) in 1981 of 187 tonnes and a natural mortality (M) of 0.29 according to Holden (1974) a total biomass of 7206 tonnes was estimated for the period of study (Table 4). This is higher than the 6000 tonnes that was estimated by Birkett (1979). Using the formula: $Y = 0.5 (C+MB)$ a maximum sustainable yield estimate of 1140 tonnes was obtained.

Skates and rays were found to occur on the continental shelf and upper regions of the slope at depths from 5 to over 800 m. Skates were restricted to depths from 250 to over 800 m by temperatures of less than 10°C and a salinity range of 34.9 to 35.1‰. Rays occurred in large numbers at depths less than 200 m with temperatures between 15 to 30.5°C and salinities of less than 34.2‰.

DISCUSSION

The skate and ray species studied show that males are smaller than females. Sexual dimorphism may separate the sexes ecologically and reduce intraspecific competition. The largest species commonly landed, *Dasyatis thetidis*, reaches a maximum total length of 205 cm, disc length 150 cm, disc width 169 cm and weight 130 kg; the smallest, *Taeniura lymna* reaches a maximum total length of 70 cm, a disc length of 45 cm, a disc width of 40 cm and a weight of 3 kg. A wide range of sizes was represented in the fishery. Data like this when collected over a long period of time might yield interesting insights into the changes of size distribution with fishing pressure. Mean body lengths, weight and biomass in terms of catch in kilogrammes under various environmental conditions could be compared over the course of developing a management strategy.

On the basis of my data, *Raja miraletus* and *Taeniura lymna* spawn in March, while *Dasyatis thetidis* spawns in November, December and January. This supports Darracott (1977) who observed that elasmobranchs along the Western Indian Ocean seek shallow waters to give birth to their young during the onset of the long rains in March. The cold waters and increased river flows into the estuarine areas during the rainy seasons may act as a trigger mechanism for spawning. The breeding of other demersal fishes occurs during or just after the rainy seasons and the Northeast Monsoon (Morgans 1962, Williams 1963, Nzioka 1979). The fecundity of skates and rays islow (Holden 1975, 1978), the number of young produced by *T. lymna* during the period of study was 13 and by *D. thetidis* between 7 and 18.

The potential fishery for skates and rays is indicated by a maximum sustainable yield of 1140 tonnes; higher than the recorded landings from small-scale fishermen (Kenya Fisheries Department Annual Report 1979). This is higher than 900 tonnes found in the study by Birkett (1979). For management purposes, it would be wise to set a yearly landing quota of less than 1140 tonnes. The highest catch rates were realised in august during the waning period of the Southwest Monsoon. This is when high primary productivity occurs along the Kenya coast (Smith and Lane 1981) and crustaceans are abundant (Heath 1973, Brusher 1974). The SW monsoon supports a higher fish biomass than the NE Monsoon (Scheffers 1982). In 1981 the average price of skates and rays was Kenyan shillings 3,240.00 per tonne. Not only are the fishes less competitively priced, but also their landings are localized and therefore the likely returns from trawling investment will be discouraging. In conclusion, this paper has presented data that infer that skates and rays could support a fishery if properly managed.

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Figure 1.

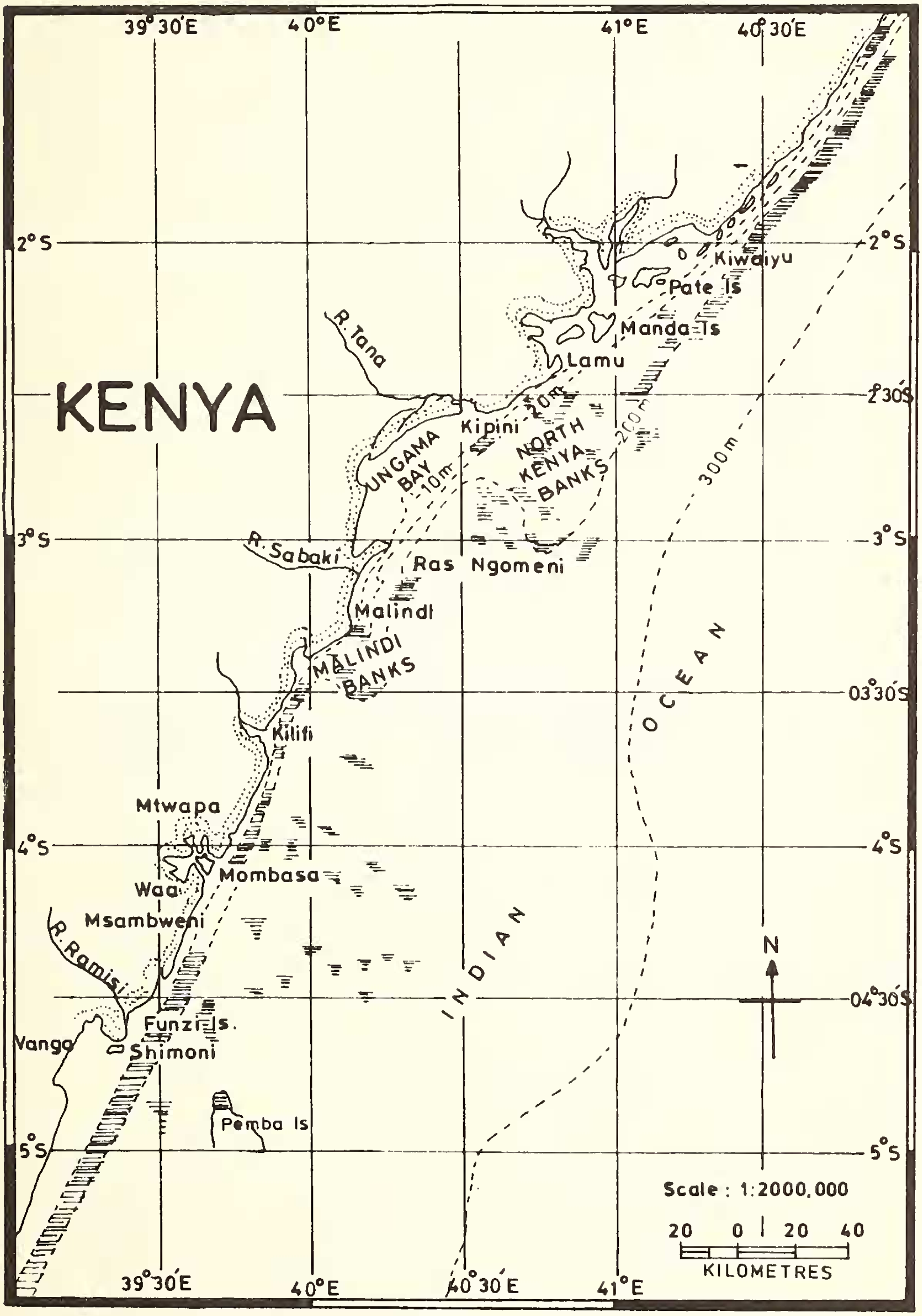

Fig. 1. The coast of Kenya showing depth contours fishing areas and fish landing station. ≡ Untrawlable areas.

Figure 2

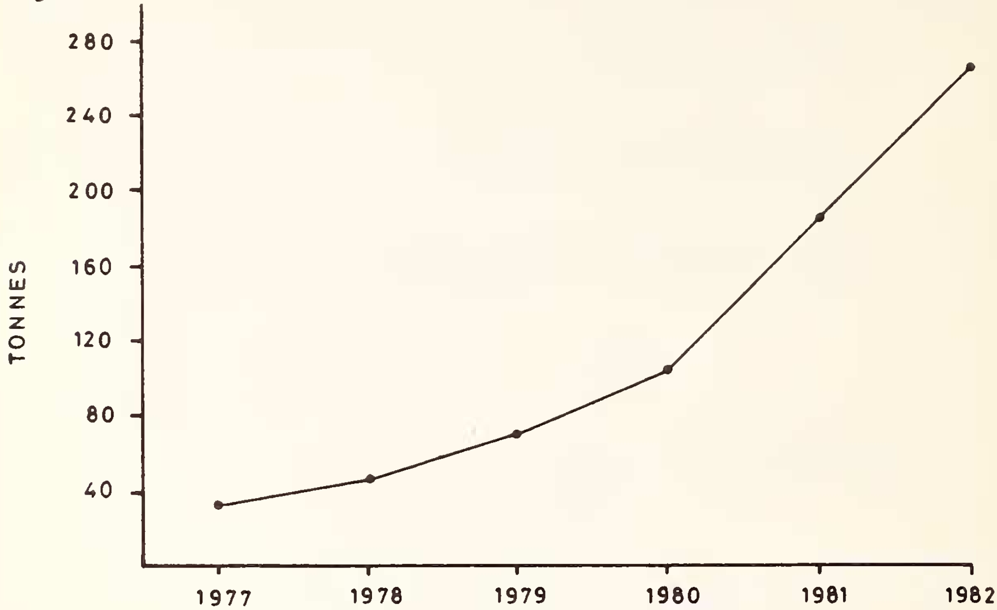

Fig 2. Landings of skates and rays along the Kenyan Coast

Figure 3.

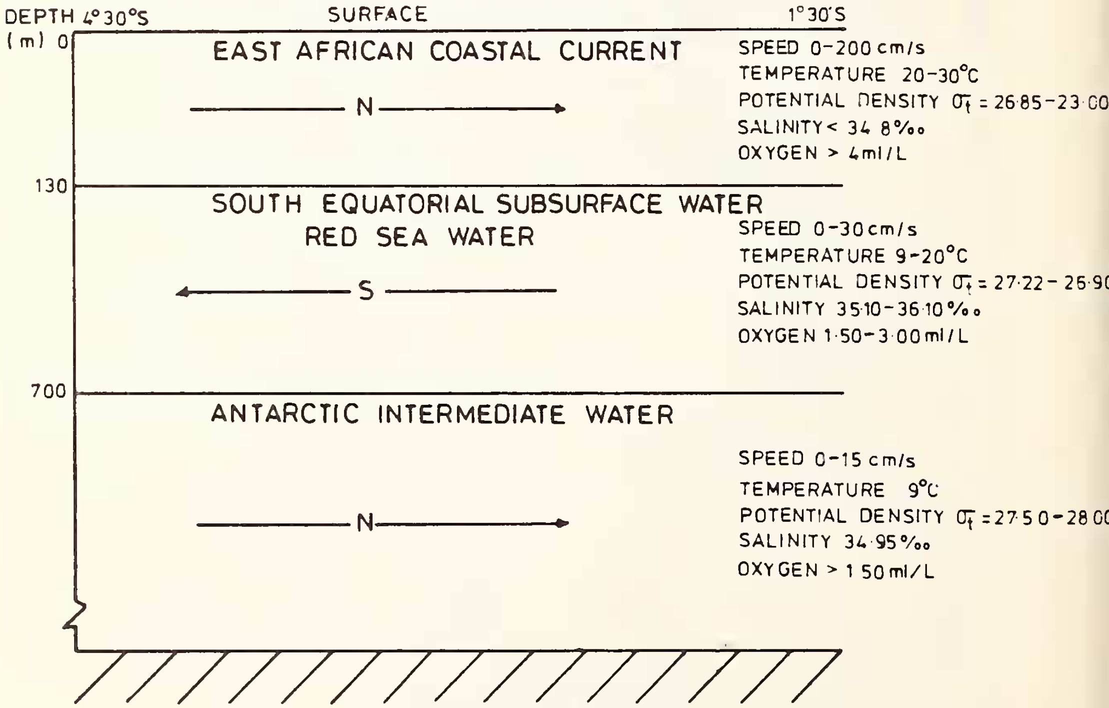

Fig 3. Currents and water mass characteristics off the Kenyan coast
⟶ shows direction of flow. N = North, S = South.

Figure 4.

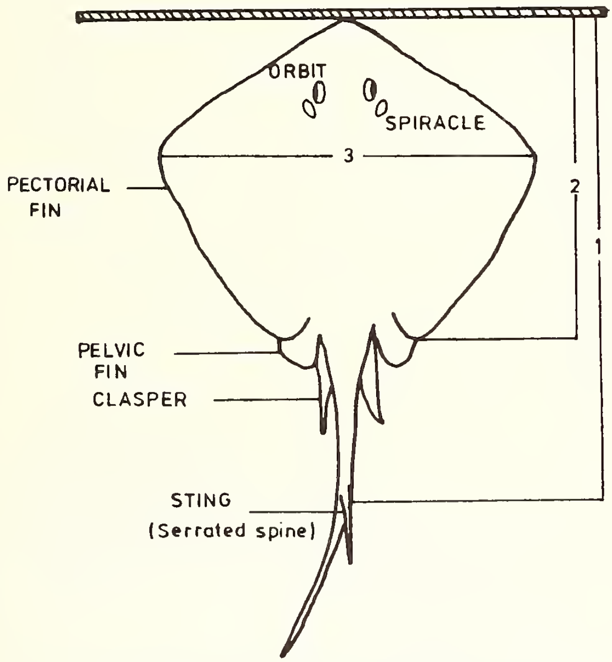

Fig. 4. Morphometric measurments taken on skate and ray specimens .

1. Total length TL
2. Disc length DL
3. Disc width DW

Figure 5.

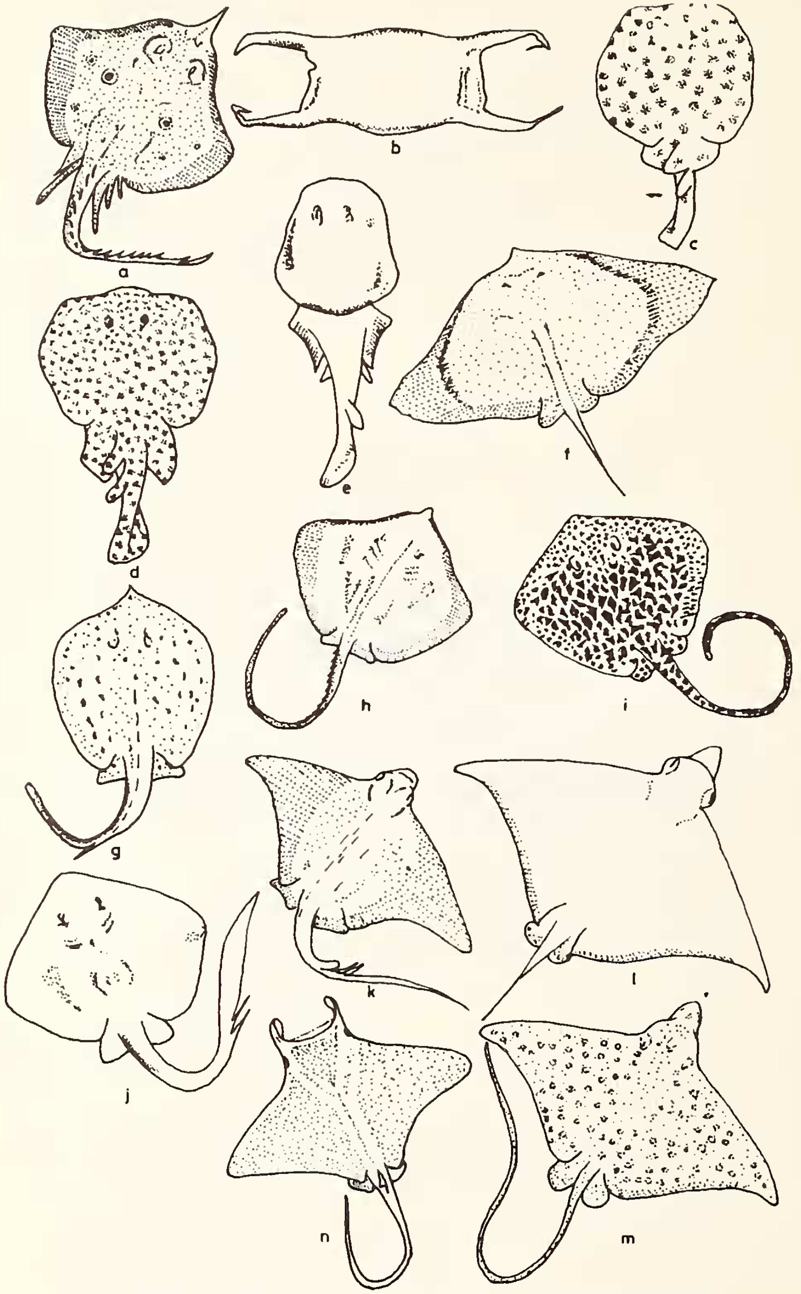

FIG.5. Line drawing of the skates and ray discussed in the papers

KEY: a) Raja miraletus, b) Raja miraletus egg case c). Tarpeda marmarata, d). Tarpeda fuscamaculata, e). Heteranarce garmani f) Gymnura natalensis g). Taeniura lymn a. h). Dasyatis thetidis i). Dasyatis uarnak j) Dasyatis sephen k) Myliabatis aquila. l). Pteramylaeus bavinus m). Aetabatis narinari. n) Manta biastris.

Figure 6

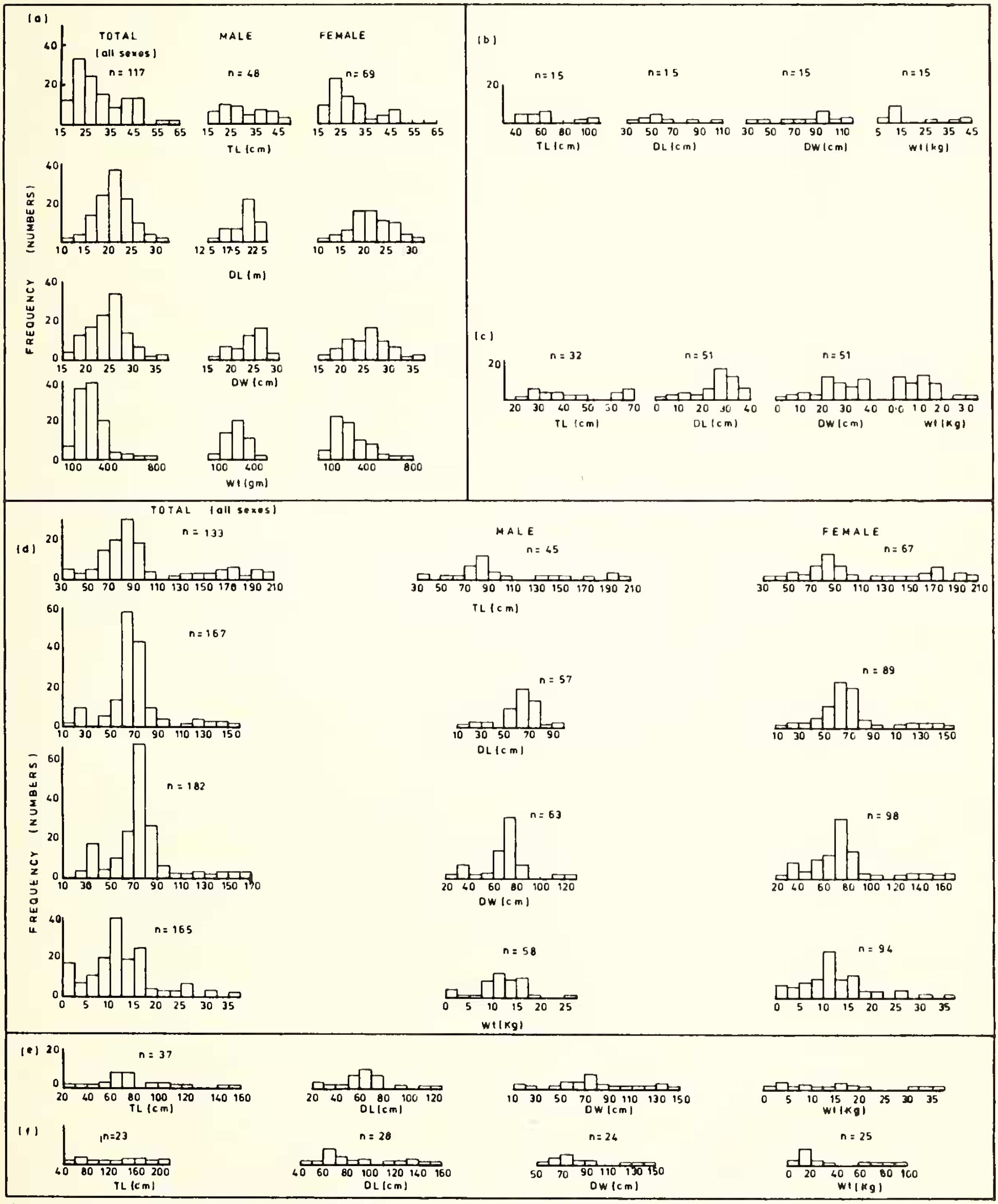

Fig 6 Length and weight histograms of the skates and Rays studied along the Kenyan Coast KEY TL = total length, DL = disc length, DW = disc width, Wt = weight. (a) Raja miraletus,(b) Myliobatis aquila,(c) Taeniura lymna,(d) Dasyatis thetidis,(e) D. uarnak and (f) D. sephen.

Figure 7

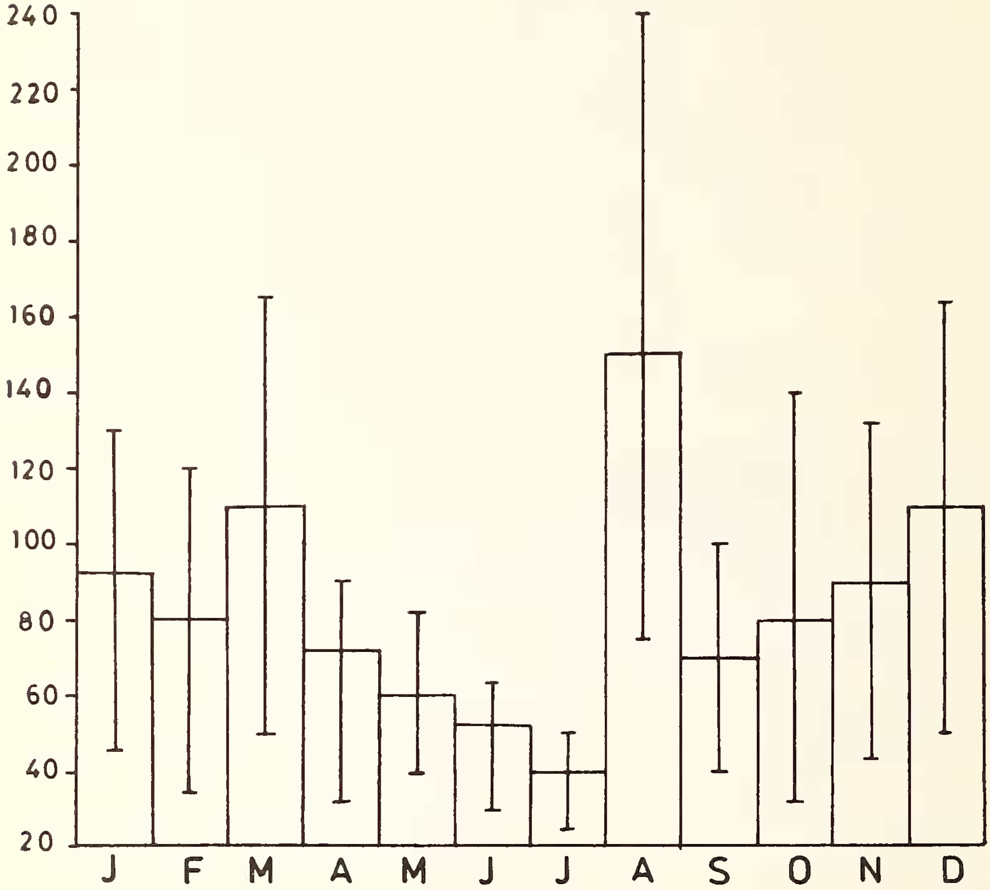

Fig. 7. Mean monthly catch rates of rays caught and landed along the Kenyan coast (vertical bars show the standard error).

Table 1

Table 1. Students t-test for the differences in mean length and weight.

	HYPOTHESIS	DECISION CRITERION	CONCLUSION AT 5% SIGNIFICANCE LEVEL
(a) *Raja miraletus*	1. Mean female TL > mean male TL	t^{x} = 0·352 > t(95,120) = 1·658	nat significant
	2. Mean female DL > mean male DL	t^{x} = 1·716 > t(95, ∝) = 1 645	significant
	3. Mean female DW > mean male DW	t^{x} = 2·177 t(95, ∝) = 1·645	significant
	4. Mean female Wt mean male Wt	t^{x} = 1·322 t(95,120) = 1·658	nat significant
(b) *Taeniura lymna*	1 DW = DL (bcth sexes)	t^{x} = 0·1043 < t(95,120) = 1·645	not significant
	2. Mean female TL > mean male TL	t^{x} = 0·107 < t(95,25) = 1·708	not significant
	3. Mean female DL > mean male DL	t^{x} = 0·787 < t(·95·40) = 1·684	not significant
	4 Mean female Wt > mean male Wt	t^{x} = 1·398 < t(·95,40) = 1·684	nat significant
(c) *Dasyatis thetidis*	1. DW = DL	t^{x} = 1·868 < t(·95,∝) = 1·645	significant
	2. Mean male TL > mean female TL	t^{x} = 1·234 > t(·95,120) = 1·658	not significant
	3. Mean female DL > mean male DL	t^{x} = 1·892 < t(·95,∝) = 1·645	significant
	4. Mean female DW > mean male DW	t^{x} = 1·895 < t(·95,∝) = 1·645	significant
	5. Mean female Wt > mean male Wt	t = 0·772 < t(·95,∝) = 1·645	not significant
(d) *Dasyatis uarnak*	1. DW > DL bath sexes	t^{x} = 0·824 < t(·95,60) = 1·960	not significant
	2. Mean male TL > mean female TL	t^{x} = 2·26 > t(·95,40) = 1·684	significant
	3. Mean male DL > mean female DL	t^{x} = 0·374 < t(·95·40) = 1·684	nat significant
	4. Mean male DW > mean female DW	t^{x} = 0·682 < t(·95,40) = 1·684	nat significant
	5 Mean female Wt > mean male Wt	t^{x} = 1 077 < t(·95,40) = 1·684	nat significant

KEY : TL = Total length
DL = disc length
DW = disc width
Wt = weight

∝ = refers ta degrees af freedam more than 120
significant = suggests evidence to conclude hypothesis
not significant = insufficient evidence

Table 2

Table 2 . Length/weight relationship for skates and rays.

SPECIES	Total length/weight relationship	Number of fish	Correlation coefficient	Male length/weight relationship	Number of fish	Correlation coefficient	Female length/weight relationship	Number of fish	coefficient
(a) *Raja miraletus*	$W = 6.98TL^{1.05}$	115	0.654	$W = 13.069TL^{0.836}$	47	W 0.651	$W = 4.509TL^{1.193}$	68	0.679
	$W = 0.09DL^{2.59}$	115	0.910	$W = 0.202DL^{2.324}$	47	0.821	$W = 0.139DL^{2.428}$	68	0.827
	$W = 0.04DW^{2.72}$	115	0.912	$W = 0.207DW^{2.204}$	47	0.807	$W = 0.0166DW^{2.98}$	68	0.956
(b) *Myliobatis aquila*	$W = 0.007TL^{1.80}$	14	0.725						
	$W = 0.222DL^{1.02}$	15	0.487						
	$W = 0.587DW^{1.22}$	15	0.679						
(c) *Toeniura lymna*	$W = 0.003TL^{1.45}$	25	0.716	$W = 0.017TL^{1.073}$	17	0.816			
	$W = 0.006DL^{1.54}$	47	0.739	$W = 0.008DL^{1.456}$	26	0.747	$W = 0.006DL^{1.548}$	20	0.708
	$W = 0.006DW^{1.53}$	47	0.792	$W = 0.005DW^{1.623}$	26	0.812	$W = 0.008DW^{1.472}$	20	0.756
(d) *Dasyatis thetidis*	$W = 0.006TL^{1.66}$	129	0.664	$W = 0.010TL^{1.510}$	41	0.585			
	$W = 0.0003DL^{2.514}$	154	0.902	$W = 0.0002DL^{2.658}$	52	0.861	$W = 0.0002DL^{2.712}$	83	0.914
	$W = 0.0003DL^{2.419}$	178	0.882	$W = 0.0004DW^{2.438}$	52	0.858	$W = 0.004DW^{1.913}$	91	0.791
(e) *D. uarnak*	$W = 0.032TL^{1.446}$	26	0.460	$W = 0.001TL^{2.261}$	15	0.907	$W = 0.006TL^{2.357}$	18	0.865
	$W = 0.0002DL^{2.68}$	26	0.897	$W = 0.0003DL^{2.634}$	15	0.929	$W = 0.0001DL^{3.057}$	18	0.339
	$W = 0.003DL^{2.022}$	37	0.883	$W = 0.006DW^{1.868}$	15	0.907	$W = 0.006DW^{1.857}$	18	0.831
(f) *D. sephen*	$W = 0.002TL^{2.027}$	23	0.891						
	$W = 0.018DL^{2.637}$	28	0.940						
	$W = 0.002DW^{2.588}$	27	0.966						

Table 3

Table 3. Data on trawl operations along the Kenyan coast by 'R V Ujuzi' showing number of hauls, their duration, depth of trawl and monthly variation in catches of "Rays"

Month		Number of Hauls	Duration (min)	Depth range	Total catch kg
1980	January	4	295	40 - 68	350
	February	10	460	35 - 65	607
	March	11	795	40 - 328	828
	April	8	870	55 - 284	486
	May	2	120	280 - 400	300
	June	—	—	—	—
	July	2	120	235 - 345	80
	August	15	1100	5 - 270	2188
	September	2	150	14 - 60	48
	October	15	1138	14 - 70	1171
	November	10	697	40 - 280	838
	December	19	985	15 - 270	1406
1981	January	8	475	25 - 280	616
	February	8	540	13 - 280	427
	March	2	180	35 - 60	48
	April	4	270	30 - 280	275
	May	1	30	7 - 15	10
	June	3	240	9 - 46	175

Table 4.

Table 4. Trawling areas, mean density and biomass for 'Rays' along the Kenya coast. (Data from RV Ujuzi FAO KEN/74/023 Project Reports 1979-81.)

Area	Trawling Areas nmi	Number of Hauls	Mean density kg/nm	Biomass estimate (tonnes)
1. North Kenya Bank (N.K.B) (01°39's to 02°48	726	43	1770	1285
Depth contour < 10 to<3000m	1259	237	34.706	4608
2. Between NKB to Malindi Banks (02°48's) to (03°26's,40°46'E)	1259	237	34.706	4608
3 Malindi Banks to Shimani Area (03°43s 40°11'E) to(04°42's 39°48'E)	1154	30	1138	1313